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Monthly Performance Report

SOUTH DAKOTA SCHOOL OF MINES

MAY 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT
SOUTH DAKOTA SCHOOL OF MINES
MAY 1979

I. SYSTEM DESCRIPTION

The South Dakota School of Mines solar energy system is installed in the visitors' center of the Mount Rushmore National Memorial at Keystone, South Dakota. The solar energy system is a retrofit to the original heating and cooling system, and is designed to provide 45 percent of the annual heating requirements for the entire building and provide 53 percent of the annual air conditioning requirements for the observation room.

Solar energy collection is performed by 112 double-glazed, flat-plate collectors manufactured by Lennox Industries, Inc., that have a gross area of 2,000 square feet. The collectors are mounted in six arrays on the roof of the building, and face 19 degrees west of south with a tilt of 46 degrees from the horizontal. The main system loop contains 150 gallons of 50 percent ethylene glycol and water solution, which is used to transfer energy, as required, from the collector to the collector-to-storage heat exchanger, the collector-to-space heating heat exchanger, and absorption chillers. Thermal storage is provided by 3,000 gallons of water in a steel storage tank that is insulated with three inches of fiberglass.

Heating demands are met by transferring energy from the collector, or storage, to heating coils in the building multizone air handler. The multizone fan is energized continuously to circulate building air, and dampers in the multizone unit are positioned to allow flow across the solar heating coil when the system is in a solar heating mode. Auxiliary heating is provided by a two-stage fuel oil furnace.

Thermal energy from the collectors is used to operate three absorption chillers; chilled water from these chillers is circulated through a cooling coil in the observation room air handler. Thermal energy from storage is

not used to operate the chillers because of temperature limitations. Auxiliary cooling is provided to both the multizone and single-zone air handlers by vapor compression units.

This system, which is shown schematically in Figure 1, has six modes of solar operation.

Mode 1 - Solar Energy Collection: The solar collection mode is entered when the collector absorber plate temperature is greater than 100°F. In this mode, pump P1 is energized and valve V4 is positioned to allow flow through the collectors. This mode is entered even though there is no heating or cooling load and storage tank charging criteria have not been met. This mode continues until the collector plate temperature is less than 100°F; however, an adjustable time-delay circuit delays pump P1 shutdown to prevent short cycling.

Mode 2 - First Stage Heating From Collectors: This mode is entered when the system is in the collection mode and a demand for heat is determined by the difference between the conditioned space thermostat setting and the discharge air temperature in the multizone air handler. In this mode, valve V7 is positioned to allow flow through the heating coil HX2 located in the multizone air handler, and valve V5 is positioned to bypass the absorption chillers. Flow through the heating coil is provided by pump P1. If the heating demand cannot be met using solar energy, a fuel-oil furnace is used in conjunction with, and independent of, solar heating.

Mode 3 - First Stage Heating From Storage: This mode is entered when there is a heating demand, energy is not available from the collectors, and energy is available from storage because the top tank temperature is greater than 100°F. In this mode, valves V5 and V7 are in the heating positions, and valve V4 is in the collection bypass position. Valves V1 and V2 are positioned to allow flow into the bottom and out of the top of the storage tank. Pump P2 is energized to circulate water between the storage tank and the water side of the storage heat exchanger HX1, and pump P1 is energized to

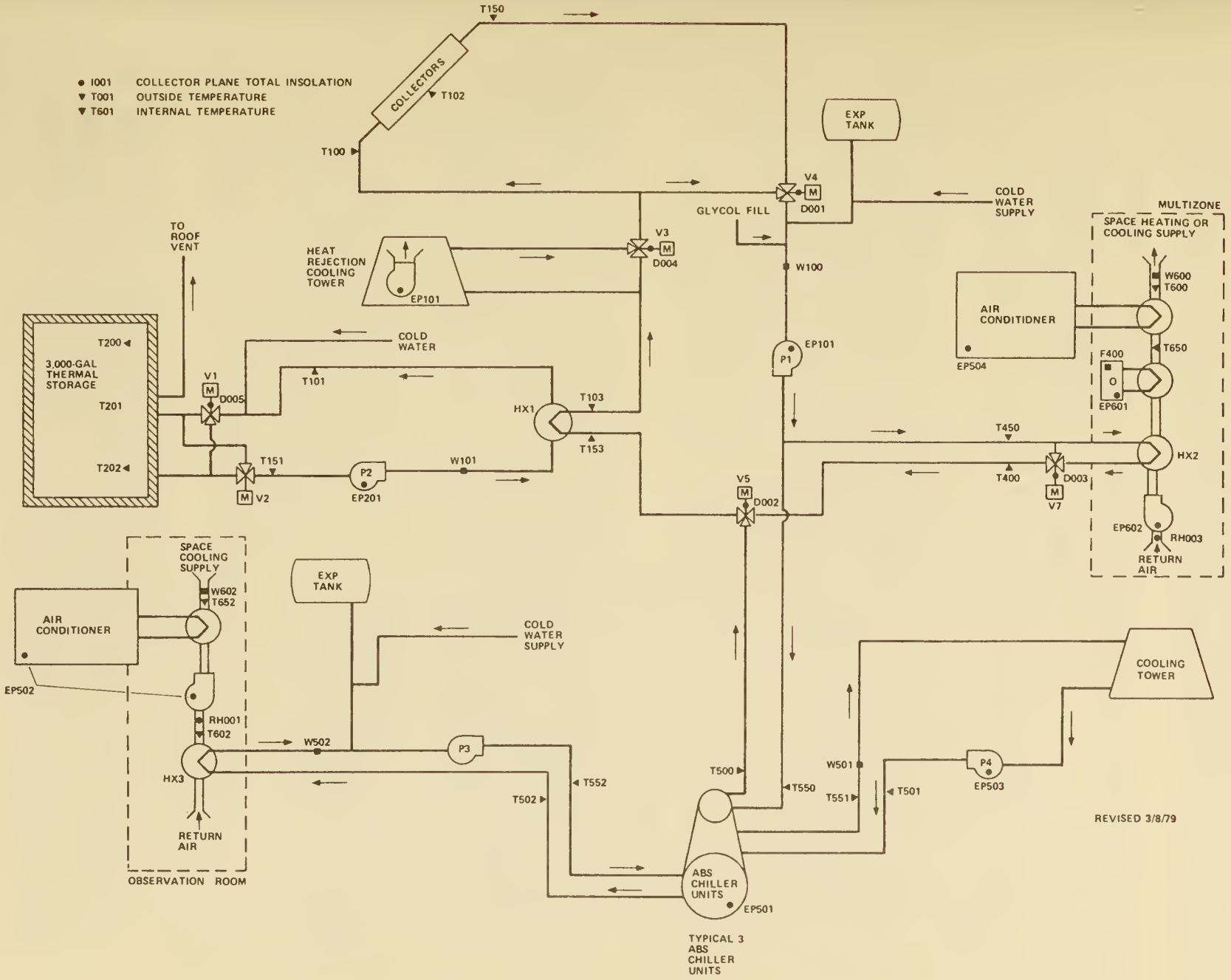

Figure 1. SOUTH DAKOTA SCHOOL OF MINES SOLAR ENERGY SYSTEM SCHEMATIC

circulate the main system fluid between the glycol/water side of exchanger HX1 and the liquid side of heating coil HX2 in the air handler. Multizone air handler and oil furnace operations are the same as described in Mode 2.

Mode 4 - Single-Zone Cooling From Collectors: This mode is entered when sufficient solar energy from the collectors is available, and when a demand for single-zone cooling is determined by the conditioned space thermostat (located in the observation room) and the discharge air temperature of single-zone air handler.

Since generator inlet temperatures of 180°F are required in order to operate the ARKLA absorption chillers, this mode is not allowed until collector outlet temperatures reach this level. If temperature requirements are met, valve V5 is positioned to allow flow through the chillers' generators, provided that pump P3 is operating to circulate chilled water through the solar cooling coils. Pump P4 is energized to circulate condensing water through the cooling tower. The cooling tower fan is controlled by an aquastat to maintain a sump temperature of 85°F.

Safety cutoffs are also provided to prevent either overheating or excessive cooling of the chillers. No solar cooling from the storage mode is provided since maximum storage tank temperature and energy losses prohibit efficient operation of the chillers. Auxiliary cooling will be provided by vapor compression units (A/C unit) in the single-zone and multizone air handlers.

Mode 5 - Storage Tank Charging: This mode is entered when the inlet temperature on the glycol/water side of the storage heat exchanger is 20°F greater than the storage tank bottom temperature. This mode is also entered in the cooling mode if, in addition to being 20°F greater than the storage temperature, the heat exchanger inlet temperature (glycol/water side) is greater than 195°F.

In this mode, valves V1 and V2 are positioned to allow flow into the top and out of the bottom of storage, and pump P2 is energized to circulate water from storage through the heat exchanger. This mode is stopped if storage tank temperatures exceed 205°F.

Mode 6 - Excess Heat Rejection: This mode is entered when the storage heat exchanger outlet temperature (T103) exceeds 205°F. In this mode, valve V3 is positioned to allow flow through the heat rejection cooling tower. The fan in this tower is controlled by an aquastat to maintain a sump temperature of 195°F.

II. PERFORMANCE EVALUATION

The system performance evaluations discussed in this section are based primarily on the analysis of the data presented in the attached computer-generated monthly report. This attached report consists of daily site thermal and energy values for each subsystem, plus environmental data. The performance factors discussed in this report are based upon the definitions contained in NBSIR 76-1137, Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program.

A. Introduction

The Mount Rushmore Visitors' Center solar energy system was operational throughout the month of May 1979. The solar contribution to the space heating load for May was very small, apparently due to improper adjustments in the control system which resulted in failure to use solar energy when it was available. Approximately three times the amount of solar energy was rejected in May (2.81 million Btu), compared with April (0.98 million Btu), and the average storage tank temperature was 10°F above the value for April, indicating the availability of energy which was not utilized. Energy was supplied from the solar energy system to the heating load on only 16 days during the month.

B. Weather

During May the measured outside ambient temperature was 51°F, which is 4°F below the long-term average for the Rapid City, South Dakota area. The measured average insolation in the plane of the collector was 1,410 Btu/ft^2-day, 17 percent below the long-term average of 1,703 Btu/ft^2-day.

Long-term environmental data are derived from data supplied by Reference Monthly Environmental Data for Systems in the National Solar Data Network, Department of Energy Report - SOLAR/0019-79/36.

C. System Thermal Performance

Collector - During the reporting period, a total of 87.44 million Btu of incident solar energy was measured in the plane of the collector array. The system collected 14.67 million Btu or 17 percent of the total available insolation. During the time the system was operating, a total of 59.42 million Btu was incident on the array. This represents an operational collector efficiency of 25 percent. A total of 0.45 million Btu of electrical energy was required to collect solar energy when the system was operating in the collection or storage modes.

Storage - Storage calculations show that 7.59 million Btu were delivered to storage during the month and 1.69 million Btu were supplied from storage. Storage losses included 6.29 million Btu from the storage tank and an additional 0.49 million Btu form the collector loop-to-storage loop heat exchanger. A net decrease in stored energy of 0.39 million Btu was observed over the month. Consequently, the monthly storage efficiency was 17 percent. The average storage tank temperature for the month was 171°F.

Space Heating Load - The space heating load for May was 12.02 million Btu. Solar energy supplied 0.87 million Btu of this load which represents a heating solar fraction of seven percent. An average building temperature of 68°F was maintained during May.

Of the 0.87 million Btu of solar energy supplied to the space heating load, 0.14 million came directly from the collector and the balance of 0.73 million Btu were supplied from storage. Operating energy required to deliver solar energy to the heating load amounted to 0.32 million Btu for the month.

D. Observations

Computations, based on the values presented in this report, yield an energy imbalance of 3.68 million Btu for the month of May, as tabulated below:

Loads and Losses (million Btu)			Solar Energy Collected by Array
Solar energy input to storage		7.590	14.670
Solar energy direct from collectors (heating)	-	0.134	
Rejected solar energy (heat purge tower)	-	2.810	
Energy loss at heat exchanger (no storage loop flow)	-	0.459	
Sum of loads and losses		10.993	-10.993
			Imbalance: 3.677 Million Btu

These computations assume nominal flow through the collectors and make no allowance for leakage conditions in the collector loop. Investigation into the probable cause of this imbalance has revealed that valve V4 (collector bypass valve, Figure 1) has a faulty actuator which prevents complete seating of the valve. The actuator is scheduled for replacement in late June 1979.

Assuming that 25 percent of nominal collector flow is diverted by the leaking valve, the apparent imbalance would be eliminated because the value of collected solar energy would be reduced to 75 percent of its present value or 11 million Btu. The load and loss terms would be unaffected by the leakage due to the placement of valve V4.

E. Energy Savings

The solar energy system at Mount Rushmore provided a savings of 1.44 million Btu of fossil fuel during May. This savings was realized at the cost of 0.45 million Btu operating energy for the solar energy system.

III. ACTION STATUS

Progress on the actuator replacement on valve V4 will be monitored during June through periodic contact with the Project Manager. Rework of the control system for more complete utilization of available solar energy is scheduled for early June 1979, concurrent with final adjustment of the air conditioning controls in preparation for the cooling season. Site data will be closely monitored to assess the effectiveness of the control adjustments.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

*SITE: SOUTH DAKOTA SCHOOL OF MINES, SD — SOLAR/2019-79/05
REPORT PERIOD: MAY,1979

SITE/SYSTEM DESCRIPTION:
THE SOUTH DAKOTA SCHOOL OF MINES SOLAR SYSTEM IS DESIGNED TO CARRY ABOUT 50% OF THE HEATING LOAD AND ABOUT 40% OF THE COOLING LOAD. SECOND STAGE HEATING WILL BE PROVIDED BY A TWO STAGE FUEL OIL BURNER AND SECOND STAGE COOLING WILL BE PROVIDED BY A REFRIGERATION COMPRESSOR IN THE MULTIZONE UNIT AND A SINGLE ZONE 10-TON PACKAGE UNIT. THE SOLAR SYSTEM WILL UTILIZE 1692 SQ-FT OF DOUBLE COVER, SELECTIVE COATED, FLAT PLATE COLLECTORS, HEATING COILS IN THE MULTI-ZONE UNIT, THREE CHILLERS, COOLING TOWER, COOLING COILS IN THE SINGLE ZONE UNIT, AND 3000 GAL. WATER STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	87.438	MILLION BTU
	43719	BTU/SQ.FT.
COLLECTED SOLAR ENERGY	14.666	MILLION BTU
	7333	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	51	DEGREES F
AVERAGE BUILDING TEMPERATURE	68	DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.01	
ECSS OPERATING ENERGY	0.448	MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.773	MILLION BTU
TOTAL ENERGY CONSUMED	34.052	MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	N.A.	12.020	-0.047	11.973	MILLION BTU
SOLAR FRACTION	N.A.	7	0	7	PERCENT
SOLAR ENERGY USED	N.A.	0.867	0.000	0.867	MILLION BTU
OPERATING ENERGY	N.A.	0.324	0.001	0.773	MILLION BTU
AUX. THERMAL ENERGY	N.A.	11.227	0.016	11.170	MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	0.023	0.023	MILLION BTU
AUX. FOSSIL FUEL	N.A.	18.711	N.A.	18.711	MILLION BTU
ELECTRICAL SAVINGS	N.A.	-0.222	0.000	-0.670	MILLION BTU
FOSSIL SAVINGS	N.A.	1.444	N.A.	1.444	MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.561

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: MAY,1979

SOLAR/2019-79/05

SITE/SYSTEM DESCRIPTION:
THE SOUTH DAKOTA SCHOOL OF MINES SOLAR SYSTEM IS DESIGNED TO CARRY ABOUT 50% OF THE HEATING LOAD AND ABOUT 40% OF THE COOLING LOAD. SECOND STAGE HEATING WILL BE PROVIDED BY A TWO STAGE FUEL OIL BURNER AND SECOND STAGE COOLING WILL BE PROVIDED BY A REFRIGERATION COMPRESSOR IN THE MULTIZONE UNIT AND A SINGLE ZONE 10-TON PACKAGE UNIT. THE SOLAR SYSTEM WILL UTILIZE 1692 SQ-FT OF DOUBLE COVER, SELECTIVE COATED, FLAT PLATE COLLECTORS, HEATING COILS IN THE MULTI-ZONE UNIT, THREE CHILLERS, COOLING TOWER, COOLING COILS IN THE SINGLE ZONE UNIT, AND 3000 GAL. WATER STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	92.247 GIGA JOULES
	496474 KJ/SQ.M.
COLLECTED SOLAR ENERGY	15.473 GIGA JOULES
	83275 KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	10 DEGREES C
AVERAGE BUILDING TEMPERATURE	20 DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.01
ECSS OPERATING ENERGY	0.472 GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.816 GIGA JOULES
TOTAL ENERGY CONSUMED	35.924 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	12.682	-0.050	12.632 GIGA JOULES
SOLAR FRACTION	N.A.	7	0	7 PERCENT
SOLAR ENERGY USED	N.A.	0.914	0.000	0.914 GIGA JOULES
OPERATING ENERGY	N.A.	0.342	0.001	0.816 GIGA JOULES
AUX. THERMAL ENG	N.A.	11.844	0.017	11.784 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	0.024	0.024 GIGA JOULES
AUX. FOSSIL FUEL	N.A.	19.741	N.A.	19.741 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	-0.234	0.000	-0.707 GIGA JOULES
FOSSIL SAVINGS	N.A.	1.524	N.A.	1.524 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.561

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978. SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: MAY,1979

SOLAR/2019-79/05

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	1.665	46	0.042	N	0.000	0.000	0.025
2	2.266	34	0.016	O	0.001	0.000	0.007
3	4.547	44	0.082	T	0.016	0.000	0.018
4	4.324	52	0.066		0.010	0.120	0.015
5	3.129	60	0.065	A	0.009	0.000	0.021
6	4.010	59	0.042	P	0.035	0.357	0.010
7	3.004	47	0.040	P	0.000	0.000	0.013
8	1.074	30	0.000	L	0.000	0.000	0.000
9	0.793	27	0.096	I	0.000	0.000	0.121
10	1.160	29	0.021	C	0.000	0.000	0.018
11	2.249	40	0.011	A	0.006	0.000	0.005
12	3.401	44	0.087	B	0.015	0.000	0.026
13	3.367	50	0.114	L	0.009	0.000	0.034
14	3.640	52	0.066	E	0.012	0.000	0.018
15	3.147	60	0.080		0.009	0.000	0.025
16	4.305	73	0.009		0.040	0.232	0.002
17	2.529	53	0.000		0.012	0.000	0.000
18	1.292	45	0.028		0.000	0.000	0.022
19	3.197	53	0.000		0.018	0.000	0.000
20	3.608	49	0.000		0.021	0.000	0.000
21	3.661	60	0.000		0.014	0.301	0.000
22	2.406	55	0.000		0.007	0.031	0.000
23	3.076	50	0.000		0.009	0.000	0.000
24	4.621	64	0.000		0.043	0.492	0.000
25	1.865	60	0.000		0.000	-0.000	0.000
26	2.903	63	0.000		0.041	0.149	0.000
27	4.236	68	0.000		0.059	0.697	0.000
28	3.169	63	0.000		0.055	0.448	0.000
29	0.671	46	0.000		0.000	-0.019	0.000
30	1.905	43	0.000		0.002	0.000	0.000
31	2.218	47	0.000		0.005	0.000	0.000
SUM	87.438	-	0.867	N.A.	0.448	2.808	-
AVG	2.821	51	0.028	N.A.	0.014	0.091	0.010
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD SOLAR/2019-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	1.665	1.119	0.152	53	0.091
2	2.266	1.523	0.302	40	0.133
3	4.547	3.859	1.144	55	0.252
4	4.324	3.815	1.027	62	0.238
5	3.129	2.666	0.633	68	0.202
6	4.010	3.556	0.948	70	0.236
7	3.004	2.399	0.464	56	0.155
8	1.074	0.040	0.006	34	0.005
9	0.793	0.000	0.000	*	0.000
10	1.160	0.015	-0.014	33	-0.012
11	2.249	1.499	0.364	48	0.162
12	3.401	2.795	0.921	51	0.271
13	3.367	2.795	0.770	57	0.229
14	3.640	3.206	0.959	62	0.263
15	3.147	2.349	0.748	74	0.238
16	4.305	2.205	0.637	87	0.148
17	2.529	1.224	0.343	51	0.135
18	1.292	0.062	-0.085	43	-0.066
19	3.197	1.993	0.411	65	0.129
20	3.608	2.999	0.617	*	0.171
21	3.661	2.994	0.668	72	0.183
22	2.406	1.224	0.358	65	0.149
23	3.076	1.629	0.236	61	0.077
24	4.621	3.629	0.786	77	0.170
25	1.865	0.034	0.022	62	0.012
26	2.903	2.324	0.384	71	0.132
27	4.236	3.851	1.049	83	0.248
28	3.169	2.833	0.521	76	0.164
29	0.671	0.000	0.000	47	0.000
30	1.905	0.232	-0.011	47	-0.006
31	2.218	0.551	0.304	53	0.137
SUM	87.438	59.419	14.666	-	-
AVG	2.821	1.917	0.473	59	0.168
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD SOLAR/2019-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.000	0.000	-0.275	177	1.000
2	0.030	0.000	-0.173	167	-5.795
3	0.644	0.000	0.438	171	0.681
4	0.319	0.000	0.080	183	0.251
5	0.126	0.000	-0.096	182	-0.761
6	0.475	0.013	0.258	184	0.570
7	0.026	0.000	-0.337	186	-12.869
8	0.000	0.000	-0.202	176	1.000
9	0.000	0.616	-0.700	166	1.000
10	0.000	0.218	-0.287	133	1.000
11	0.110	0.000	0.004	130	0.038
12	0.487	0.000	0.379	139	0.778
13	0.344	0.000	0.215	151	0.625
14	0.424	0.000	0.251	160	0.592
15	0.360	0.000	0.166	170	0.460
16	0.575	0.021	0.017	173	0.065
17	0.206	0.057	0.077	177	0.650
18	0.000	0.126	-0.290	170	1.000
19	0.343	0.022	0.153	168	0.509
20	0.533	0.000	0.297	178	0.558
21	0.296	0.055	0.005	187	0.200
22	0.182	0.028	-0.037	185	-0.047
23	0.209	0.026	0.005	183	0.144
24	0.449	0.116	-0.015	185	0.226
25	0.000	0.008	-0.297	174	1.000
26	0.272	0.104	0.092	176	0.720
27	0.675	0.166	0.214	177	0.563
28	0.372	0.016	-0.018	175	-0.006
29	0.000	0.064	-0.084	179	1.000
30	0.019	0.036	-0.182	174	-7.812
31	0.119	0.000	-0.049	169	-0.417
SUM	7.595	1.691	-0.394	-	-
AVG	0.245	0.055	-0.013	171	0.171
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: MAY, 1979

SCLAR/2019-79/05

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.608	7	0.042	0.021	0.566	N	0.944	-0.015	0.070	67	46
2	0.768	2	0.016	0.022	0.753	O	1.255	-0.014	0.026	64	34
3	0.643	13	0.082	0.026	0.560	T	0.934	-0.020	0.137	67	44
4	0.382	17	0.066	0.024	0.316		0.526	-0.020	0.111	69	52
5	0.247	26	0.065	0.016	0.182	A	0.303	-0.014	0.109	71	60
6	0.042	100	0.042	0.004	0.000	P	0.000	-0.004	0.070	70	59
7	0.147	27	0.040	0.024	0.106	P	0.177	-0.024	0.067	67	47
8	1.081	0	0.000	0.009	1.081	L	1.802	-0.002	0.000	63	30
9	1.346	7	0.096	0.030	1.245	I	2.074	-0.018	0.160	62	27
10	1.510	1	0.021	0.025	1.489	C	2.482	-0.010	0.036	62	29
11	1.099	1	0.011	0.026	1.088	A	1.813	-0.015	0.018	64	40
12	1.098	8	0.087	0.022	1.010	B	1.684	-0.011	0.146	65	44
13	0.753	15	0.114	0.025	0.638	L	1.064	-0.018	0.190	68	50
14	0.443	15	0.066	0.025	0.377	E	0.629	-0.020	0.110	69	52
15	0.384	21	0.080	0.015	0.304		0.507	-0.012	0.133	71	60
16	0.009	100	0.009	0.002	0.078		0.130	-0.002	0.015	73	73
17	0.000	0	0.000	0.000	0.000		0.000	-0.000	0.000	70	53
18	0.475	6	0.028	0.003	0.446		0.744	-0.001	0.047	69	45
19	0.347	0	0.000	0.002	0.347		0.578	0.000	0.000	70	53
20	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	68	49
21	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	69	60
22	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	69	55
23	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	68	50
24	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	70	64
25	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	71	60
26	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	72	63
27	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	73	68
28	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	74	63
29	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	69	46
30	0.000	0	0.000	0.000	0.000		0.000	0.000	0.000	65	43
31	0.639	0	0.000	0.004	0.639		1.065	0.000	0.000	67	47
SUM	12.020	-	0.867	0.324	11.227	N.A.	18.711	-0.222	1.444	-	-
AVG	0.388	7	0.028	0.010	0.362	N.A.	0.604	-0.007	0.047	68	51
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
Ø DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE COOLING SUBSYSTEM

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: MAY, 1979

SCLAR/2019-79/05

DAY OF MON.	SPACE COOLING LOAD MILLION BTU	SOLAR FR. OF LOAD PCT	SCLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG DRY BULB TEMP F	AMB TEMP DEG F
1	0.000	0	0.000	0.000	0.000	0.000	N	0.000	N	67	46
2	0.000	0	0.000	0.000	0.000	0.000	O	0.000	O	64	34
3	0.000	0	0.000	0.000	0.000	0.000	T	0.000	T	67	44
4	0.000	0	0.000	0.000	0.000	0.000		0.000		69	52
5	0.000	0	0.000	0.000	0.000	0.000	A	0.000	A	71	60
6	0.000	0	0.000	0.000	0.000	0.000	P	0.000	P	70	59
7	0.000	0	0.000	0.000	0.000	0.000	P	0.000	P	67	47
8	0.000	0	0.000	0.000	0.000	0.000	L	0.000	L	63	30
9	0.000	0	0.000	0.000	0.000	0.000	I	0.000	I	62	27
10	0.000	0	0.000	0.000	0.000	0.000	C	0.000	C	62	29
11	0.000	0	0.000	0.000	0.000	0.000	A	0.000	A	64	40
12	0.000	0	0.000	0.000	0.000	0.000	B	0.000	B	65	44
13	0.000	0	0.000	0.000	0.000	0.000	L	0.000	L	68	50
14	0.000	0	0.000	0.000	0.000	0.000	E	0.000	E	69	52
15	0.000	0	0.000	0.000	0.000	0.000		0.000		71	60
16	0.000	0	0.000	0.000	0.000	0.000		0.000		73	73
17	0.000	0	0.000	0.000	0.000	0.000		0.000		70	53
18	0.000	0	0.000	0.000	0.000	0.000		0.000		69	45
19	0.000	0	0.000	0.000	0.000	0.000		0.000		70	53
20	0.000	0	0.000	0.000	0.000	0.000		0.000		68	49
21	0.000	0	0.000	0.000	0.000	0.000		0.000		69	60
22	0.000	0	0.000	0.000	0.000	0.000		0.000		69	55
23	0.000	0	0.000	0.000	0.000	0.000		0.000		68	50
24	-0.047	0	0.000	0.001	0.016	0.023		0.000		70	64
25	0.000	0	0.000	0.000	0.000	0.000		0.000		71	60
26	0.000	0	0.000	0.000	0.000	0.000		0.000		72	63
27	0.000	0	0.000	0.000	0.000	0.000		0.000		73	68
28	0.000	0	0.000	0.000	0.000	0.000		0.000		74	63
29	0.000	0	0.000	0.000	0.000	0.000		0.000		69	46
30	0.000	0	0.000	0.000	0.000	0.000		0.000		65	43
31	0.000	0	0.000	0.000	0.000	0.000		0.000		67	47
SUM	-0.047	-	0.000	0.001	0.016	0.023	N.A.	0.000	N.A.	-	-
AVG	-0.002	0	0.000	0.000	0.000	0.001	N.A.	0.000	N.A.	68	51
NBS	Q502	N500	Q500	Q503	Q501		Q508	Q512	Q514	N406	N113

* DENOTES UNAVAILABLE DATA.
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N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: MAY,1979

SOLAR/2019-79/05

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	832	N	46	53	N	N	N
2	1133	O	34	40	O	C	O
3	2273	T	44	55	T	T	T
4	2162		52	62			
5	1565	A	60	68	A	A	A
6	2005	P	59	70	P	P	P
7	1502	P	47	56	P	P	P
8	537	L	30	34	L	L	L
9	396	I	27	*	I	I	I
10	580	C	29	33	C	C	C
11	1125	A	40	48	A	A	A
12	1700	B	44	51	B	B	B
13	1683	L	50	57	L	L	L
14	1820	E	52	62	E	E	E
15	1574		60	74			
16	2153		73	87			
17	1265		53	51			
18	646		45	43			
19	1598		53	65			
20	1804		49	*			
21	1830		60	72			
22	1203		55	65			
23	1538		50	61			
24	2310		64	77			
25	933		60	62			
26	1452		63	71			
27	2118		68	83			
28	1585		63	76			
29	335		46	47			
30	953		43	47			
31	1109		47	53			
SUM	43719	N.A.	-	-	-	-	-
AVG	1410	N.A.	51	59	N.A.	N.A.	N.A.
NBS ID	Q001		N113			N115	N114

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